New Method for Generalised PR Target Design for Perpendicular Magnetic Recording

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I. Introduction

In recent years, perpendicular magnetic recording (PMR) has been the main topic of interest in the industry. Given current estimates, that would suggest an areal density using PMR as great as one terabit per square inch – making possible in two to three years a 3.5-inch disk drive capable of storing an entire terabyte of data [1]. As the areal density is increased, however, the signal processing aspects of magnetic recording becomes more difficult.

The present technique for finding the optimised GPR targets is based on the minmimum mean squared error (MMSE) between the equaliser output and the desired output, subject to the monic constraint [2]. In this paper, we present a new method of designing GPR targets for PMR. This method is based on maximising the ratio of minimum squared eucledian distance of the PR target to the noise penalty introduced by the PR filter. The description of the channel model and the new method follows in the next section and the results and comparison follows after that.

II. Simulation Model

Figure(1(a)) shows the block diagram of the PMR system model used in this paper. The user data, denoted as a_k, is a sequence of input symbols taking values of $0, 1$. To simulate the write current, the sequence a_k is mapped to $-1, +1$. The scaling factor of 0.5 is to ensure the transition takes values of $-1, 0, +1$. We approximate the single-transition step repsonse, denoted as $s(t)$, using the hyperbolic tangent function [3][4]:

$$s(t) = A \cdot \tanh\left(\ln(3)\frac{t}{PW_{50}}\right) \tag{1}$$

where A is the saturation level/amplitude from zero to peak(normalised to unity) and PW_{50} is the time taken for $s(t)$ to go from $-A/2$ to $+A/2$. It is assumed that t and PW_{50} are normalised to the symbol period, T. The dibit response $p(t)$ is defined as:

$$p(t) = s(t) - s(t-1) \tag{2}$$

The readback signal $r(t)$ is the convolution of a_k and $p(t)$ plus some Additive White Gaussian Noise (AWGN):

$$r(t) = \underbrace{\sum_k a_k p(t-kT)}_{\text{b(t)}} + n(t) \tag{3}$$

where $n(t)$ is the AWGN with mean of 0 and variance of σ^2. A Maximum Likelihood Sequence Detector (MLSD) is used to provide the decoder solution which is used for performance evaluation.

III. GPR Target Search Method

The present technique [2] for achieving optimised GPR target is optimal only if the receiver has noise prediction. If there is no noise prediction, then the equaliser leads to additional noise. This is as shown in figure(1(b)). Considering a PR equaliser with a monic constraint,where $h(0) = 1$, the new technique described in this paper is based on the calculation of ratio of the minimum squared eucledian distance of the PR scheme under this monic constraint to the squared noise penalty introduced by the filter. Consider the N tap coefficients $h(\frac{N-1}{2}), \cdots, \cdots, h(\frac{N-1}{2})$, where N is an odd integer. The equalised signal y is:

$$\begin{aligned} y &= r(t) * h(t) \\ &= b(t) * h(t) + n(t) * h(t) \\ &= b(t) * h(t) + n(t) + n_f(t) \end{aligned} \tag{4}$$

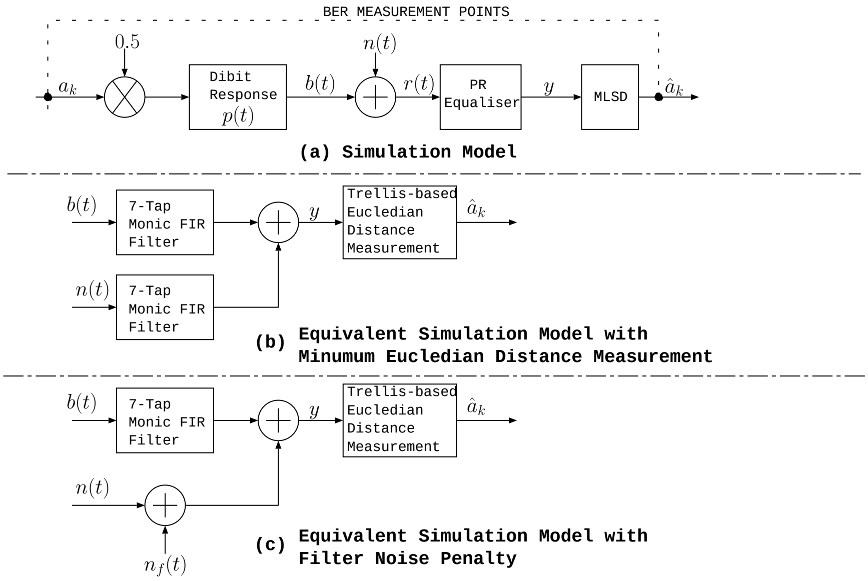

Figure 1: Simulation Block including GPR Target Search

PW_{50}	Target
1.3	[1,4,7,3]
1.4	[1,5,8,4]
1.5	[1,5,8,4]

Figure 2: GPR Target Results

Here, $n_f(t)$ is the noise penalty from the filter. The analysis of the system is shown in Figure 1.

The rule of optimisation is to find the GPR target that maximises the ratio of minimum squared euclidean distance on the trellis over the noise penalty. Thus, the effective design ratio is:

$$\text{Design Ratio} = \frac{\text{Minimum Squared Eucledian Distance}}{\text{Filter Noise Penalty}} \tag{5}$$

where, the filter noise penalty is computed as,

$$\text{Filter Noise Penalty} = \sum_{\forall j, j \neq 0} h(j)^2 \tag{6}$$

The optimsed search looks for the PR target that maximises this Design Ratio. Results from this are in Figure 2.

Results and Discussions

The GPR targets obtained using this new method for GPR search are the same with traditional method of GPR search for most PW_{50}. This new method provides consistently equal or better targets for PRML schemes that does not include noise prediction. Future work will focus on investigating the effect of media noise.

References

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